

A collage-style illustration. On the left, a globe shows a weather pattern with purple and orange swirling lines. To its right is a map of South America in yellow. A red banner with the text 'El Niño' in black cursive script is draped across the center. The background includes a blue sky with white clouds and a blue ocean. At the bottom, the words 'West', 'Pacific Ocean', and 'East' are written in a serif font.

El Niño

West

Pacific Ocean

East

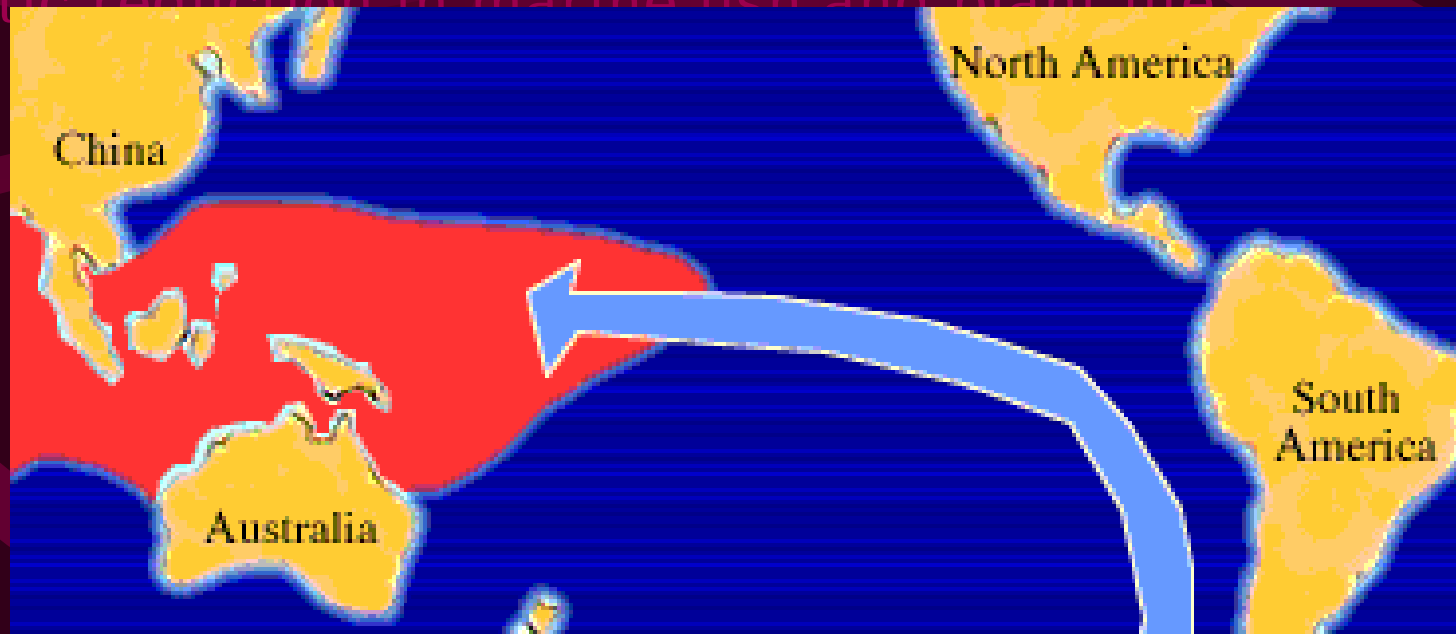
El Niño a warm current of water

El Niño (Spanish name for the male child), initially referred to a weak, warm current appearing annually around Christmas time along the coast of Ecuador and Peru and lasting only a few weeks to a month or more. Every three to seven years, an El Niño event may last for many months, having significant **economic** and **atmospheric** consequences worldwide. During the past forty years, ten of these major El Niño events have been recorded, the worst of which occurred in **1997-1998**.

Previous to this, the El Niño event in 1982-1983 was the strongest. Some of the El Niño events have persisted more than one year.

El Niño years			
1902-	1905-	1911-	1914-
1903	1906	1912	1915
1918-	1923-	1925-	1930-
1919	1924	1926	1931
1932-	1939-	1941-	1951-
1933	1940	1942	1952
1953-	1957-	1965-	1969-
1954	1958	1966	1970
1972-	1976-	1982-	1986-
1973	1977	1983	1987
1991-	1994-	1997-199	
1992	1995	9	

In the tropical Pacific, **trade winds** generally drive the surface waters westward. The surface water becomes progressively warmer going westward because of its longer exposure to solar heating. El Niño is observed when the easterly trade winds weaken, allowing warmer waters of the western Pacific to migrate eastward and eventually reach the South American Coast (shown in orange). The cool nutrient-rich sea water normally found along the coast of Peru is replaced by warmer water depleted of nutrients, resulting in a **dramatic reduction in marine fish and plant life**.



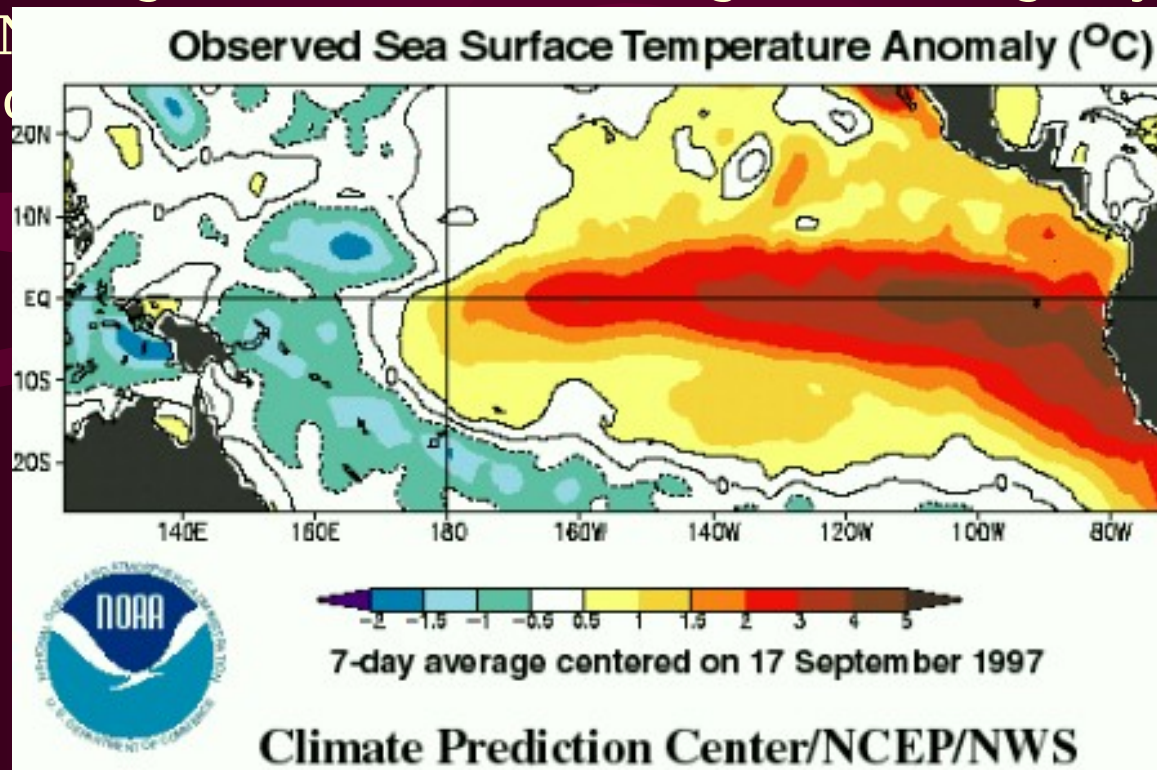
In contrast to El Niño, La Niña (female child) refers to an anomaly of unusually cold sea surface temperatures found in the eastern tropical Pacific. La Niña occurs roughly half as often as El Niño.

La Niña Years

1904-1905	1909-1910	1910-1911	1915-1916
1917-1918	1924-1925	1928-1929	1938-1939
1950-1951	1955-1956	1956-1957	1964-1965
1970-1971	1971-1972	1973-1974	1975-1976
1988-1989	1995-1996		

1997-1998 El Niño the most recent

The most recent El Niño event began in the spring months of 1997. Instrumentation placed on Buoys in the Pacific Ocean after the 1982-1983 El Niño began recording abnormally high temperatures off the coast of Peru. Over the next couple of months, these strength of these anomalies grew. The anomalies grew so large by October 1997 that this El Niño was the strongest in the 50+ years of accurate observation.

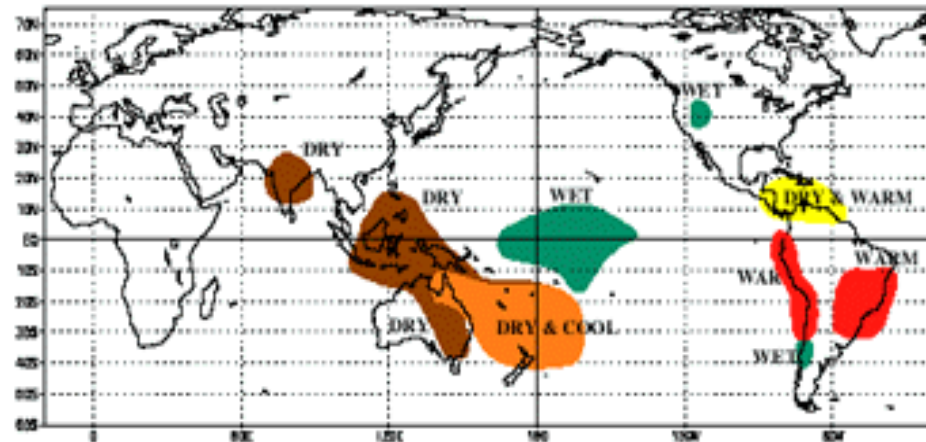


The image above displays the Sea Surface Temperature (SST) Anomalies in degrees Celsius for the middle of September, 1997. By this time, the classic El Niño pattern has almost fully ripened, with

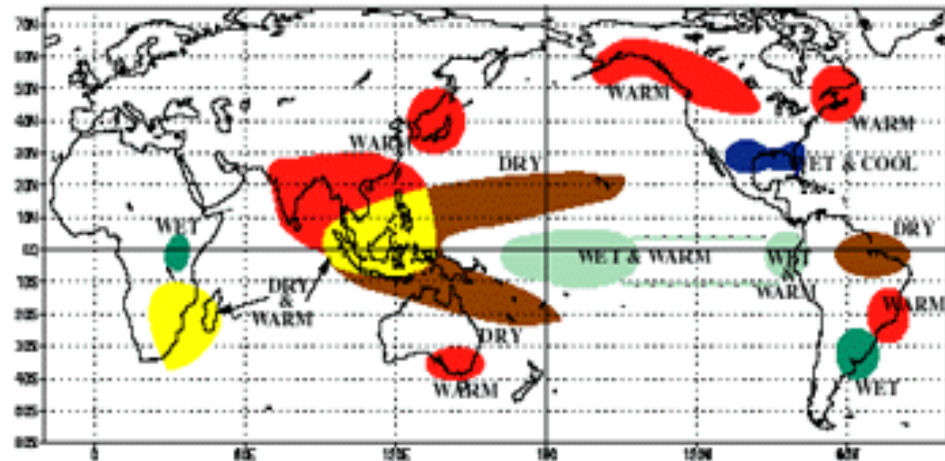
Droughts in the Western Pacific Islands and Indonesia as well as in Mexico and Central America were the early (and sometimes constant) victims of this El Niño. These locations were consistent with early season El Niños in the past. A global view of the normal climatic effects of El Niño can be seen in the following maps.

The effects El Niño have on United States' weather is less obvious. Back in 1982-1983, the U.S. Gulf States and California received excessive rainfall. As the winter approached, forecasters expected excessive rainfall to occur again. Indeed, portions of central and southern California suffered record-breaking rainfall amounts. Damage consisted not only of flooding, but mudslides. Some mudslides destroyed communities in a flash -- causing many casualties. Other problems could be found in the Gulf states, as severe weather was above average. Even though no one particular storm

WARM EPISODE RELATIONSHIPS JUNE - AUGUST



WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



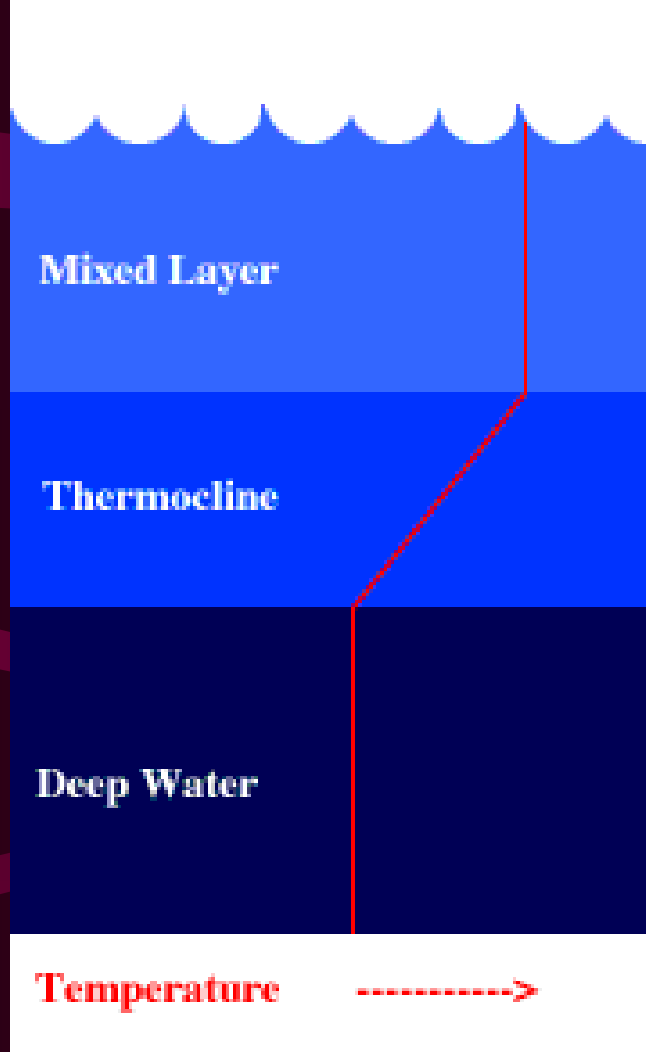
Upwelling

the transport of deeper water to shallow levels

One oceanic process altered during an El Niño year is upwelling, which is the rising of deeper colder water to shallower depths. The diagram below shows how upwelling occurs along the coast of Peru. Because of the frictional stresses that exist between ocean layers, surface water is transported at a 90 degree angle to the left of the winds in the southern hemisphere, 90 degrees to the right of the winds in the northern hemisphere. This is why winds blowing northward parallel to the coastline of Peru "drag" surface water westward away from shore.



Nutrient-rich water rises from deeper levels to replace the surface water that has drifted away and these nutrients are responsible for supporting the large fish population commonly found in these areas. The effectiveness of upwelling and its ability to support abundant sea life is greatly dependent upon the health of the ecosystem.

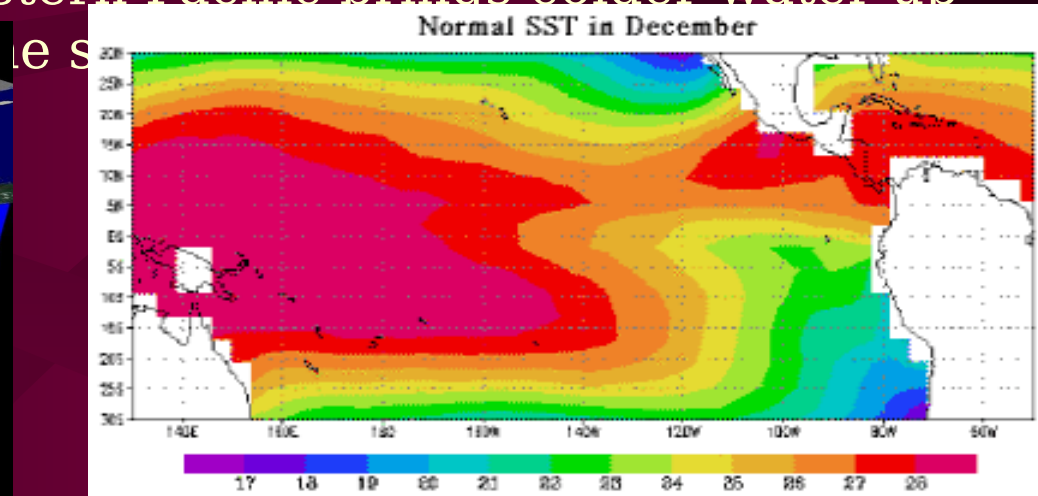
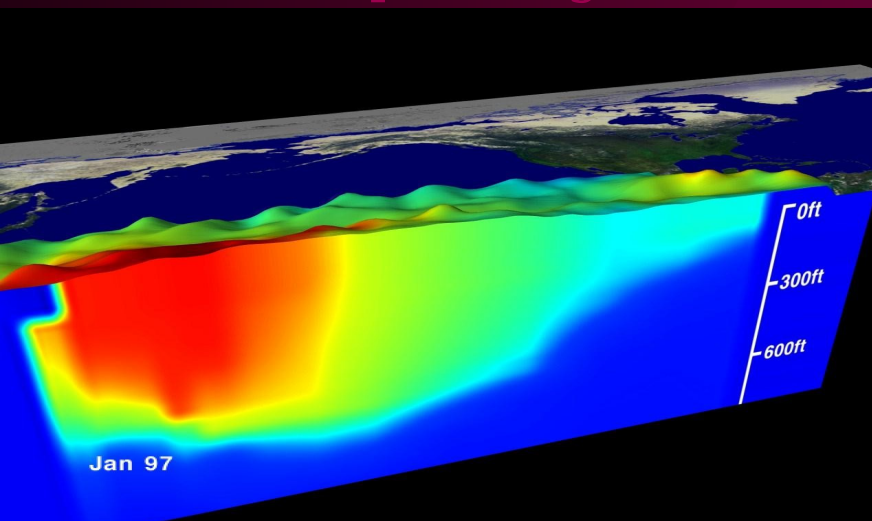


The thermocline is the transition layer between the mixed layer at the surface and the deep water layer. The definitions of these layers are based on temperature. The mixed layer is near the surface where the temperature is roughly that of surface water. In the thermocline, the temperature decreases rapidly from the mixed layer temperature to the much colder deep water temperature. The mixed layer and the deep water layer are relatively uniform in temperature, while the thermocline represents the transition zone between the two.

A deeper thermocline (often observed during El Niño years) limits the amount of nutrients brought to shallower depths by upwelling processes,

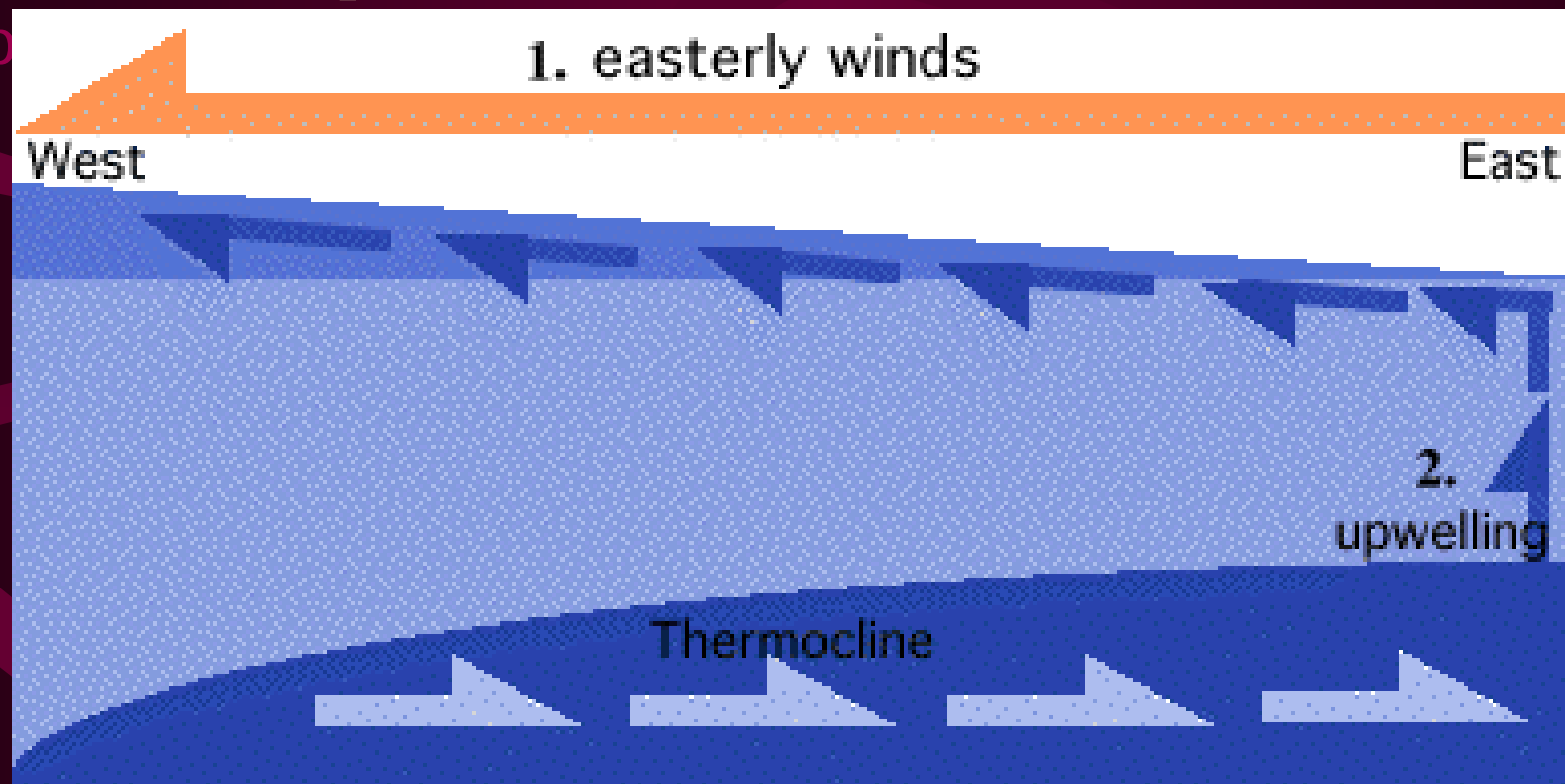
Non El Niño Years colder water in the eastern tropical Pacific

The easterly trade winds of the tropics drag the surface waters of the eastern Pacific away from the coastlines of the Americas. As it moves away, the water is deflected northward (in the northern hemisphere) by the Coriolis force and southward (in the southern hemisphere), causing water to move away from the equator in both directions. Upwelling in the eastern Pacific brings colder water up

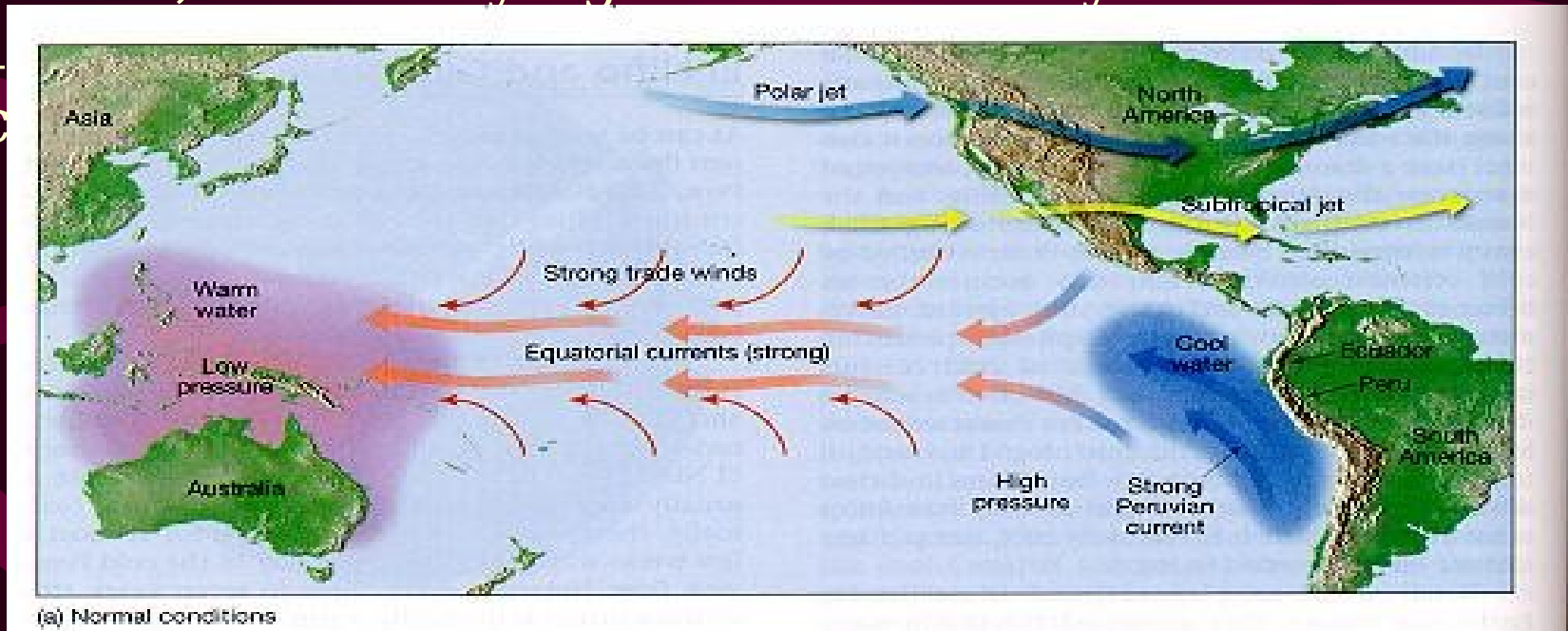


Sea surface temperature (SST) data reveals the presence of colder water in the eastern tropical Pacific. The following plot of average sea surface temperatures from 1949-1993 shows that the average December SSTs were much cooler in the eastern Pacific (less than 22 degrees Celsius) than in the western Pacific (greater than 25 degrees Celsius), gradually decreasing from west to east.

The **trade winds** accumulate warm surface water around Indonesia, raising the sea level roughly half a meter higher in the western Pacific. As **upwelling** persists, the level of the **thermocline** rises to shallower depths off the South American coast and is depressed in the western Pacific. The upwelled water is rich in nutrients and



As surface water propagates westward, it is heated by the atmosphere and the sun, allowing warmer waters to accumulate in the western Pacific. The cooler water in the eastern Pacific cools the air above it, and consequently the air becomes too dense to rise and produce clouds and rain. In the western Pacific however, the overlying air is heated by the warmer water, and consequently the air becomes less dense and rises, producing clouds and rain.



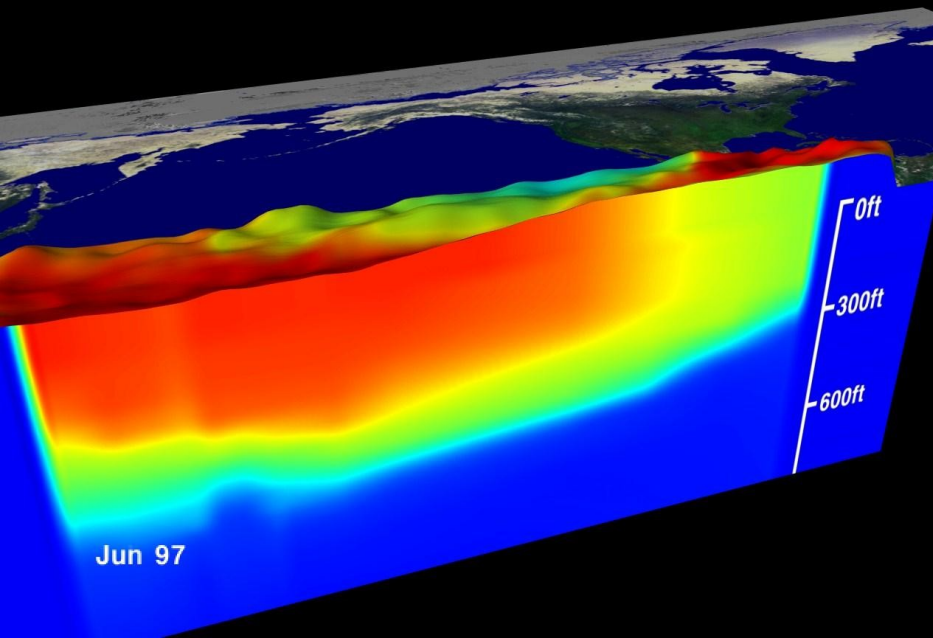
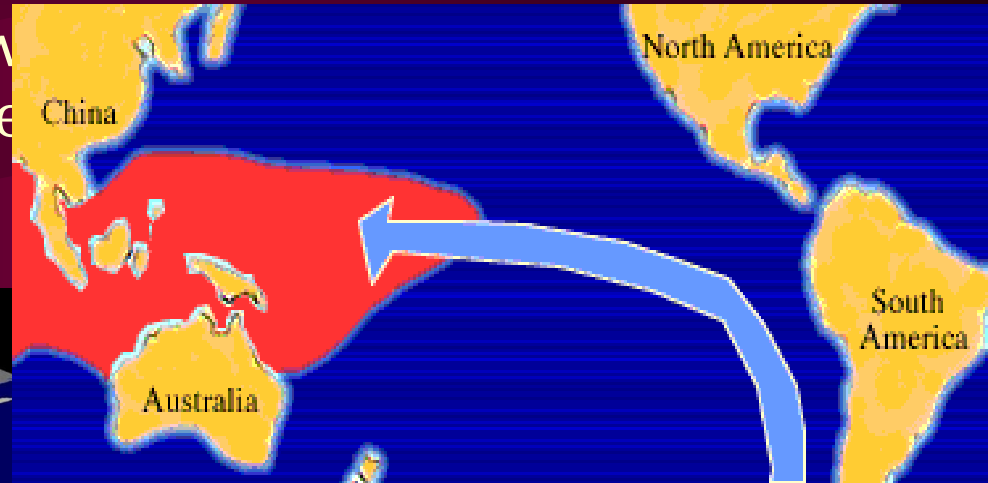
This is why during most non El Niño Years, heavy rainfall is found over the warmer waters of the western Pacific (near Indonesia) while the eastern Pacific is relatively dry.

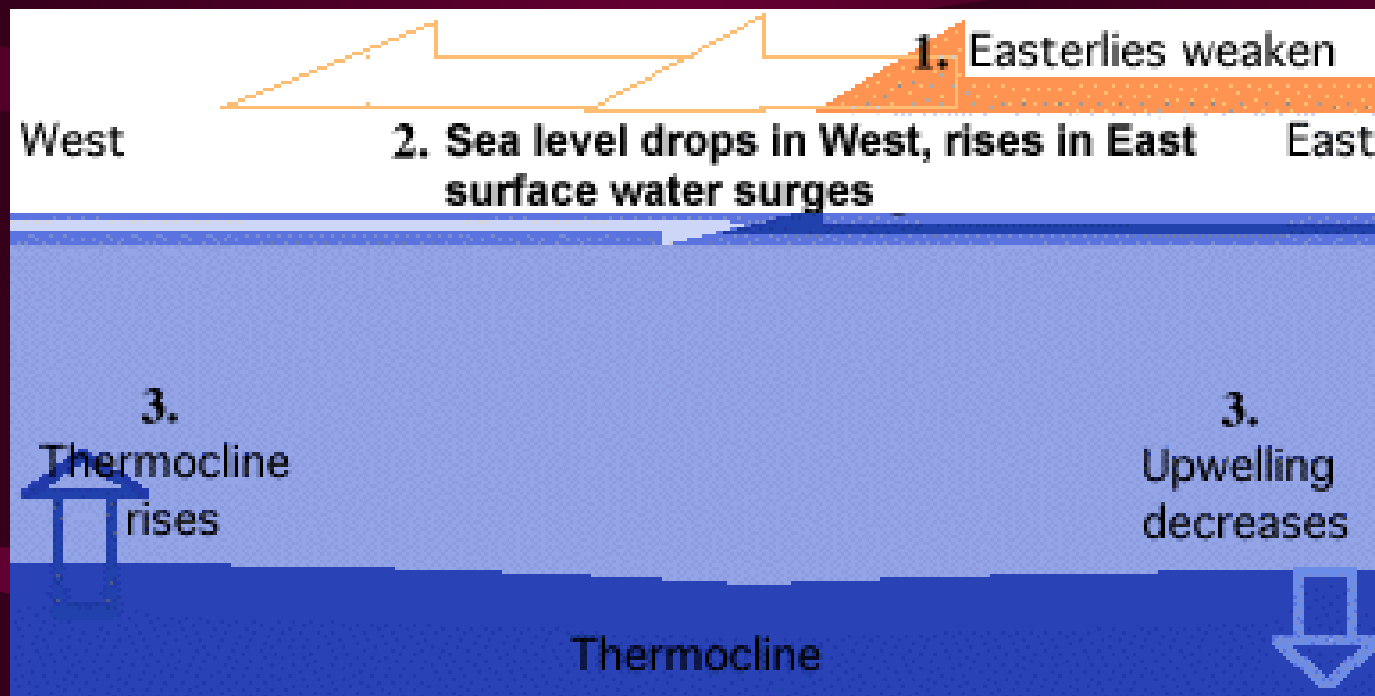
El Niño Events

results from weakening easterly

trade winds

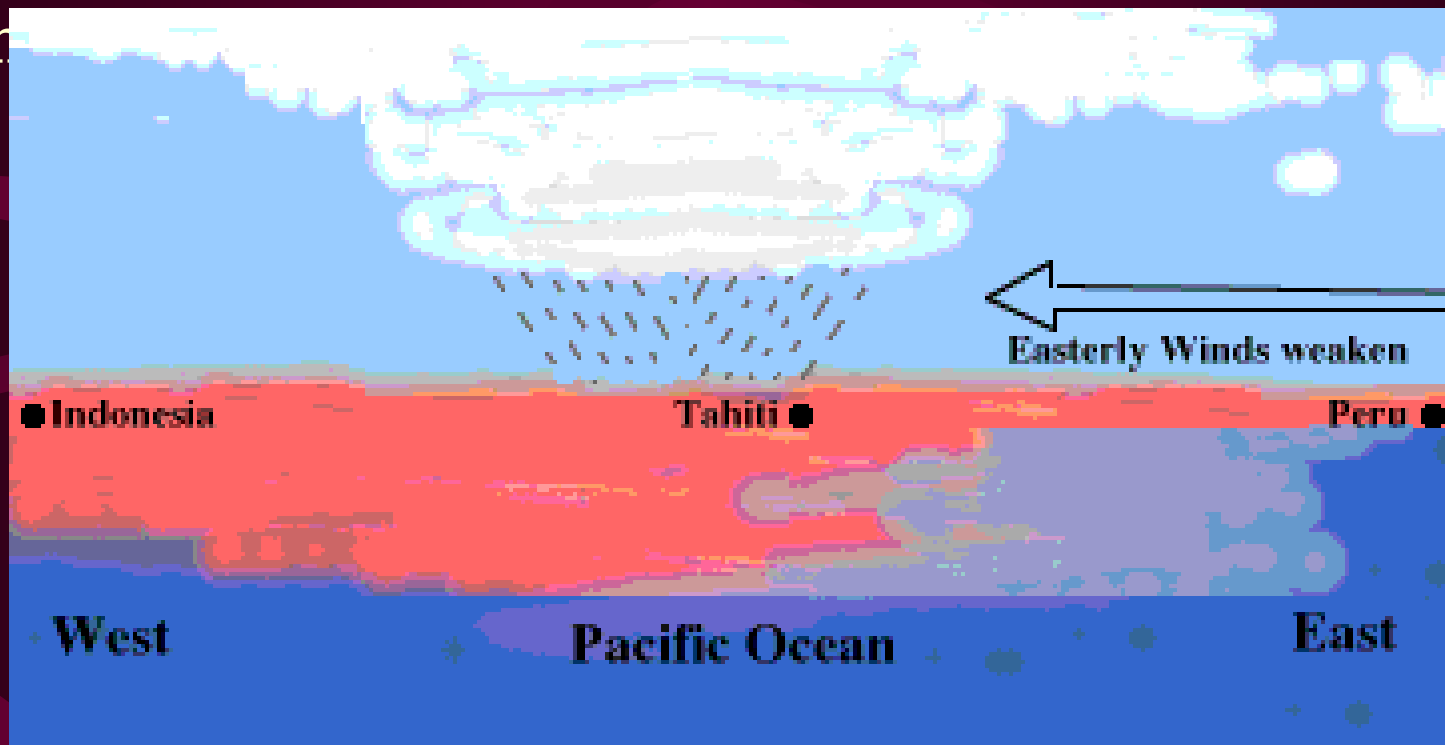
The easterly trade winds are driven by a surface pressure pattern of higher pressure in the eastern Pacific and lower pressure in the west. When this pressure gradient weakens, so do the trade winds. The weakened trade winds allow warmer water from the west to move eastward, so the sea level flattens.



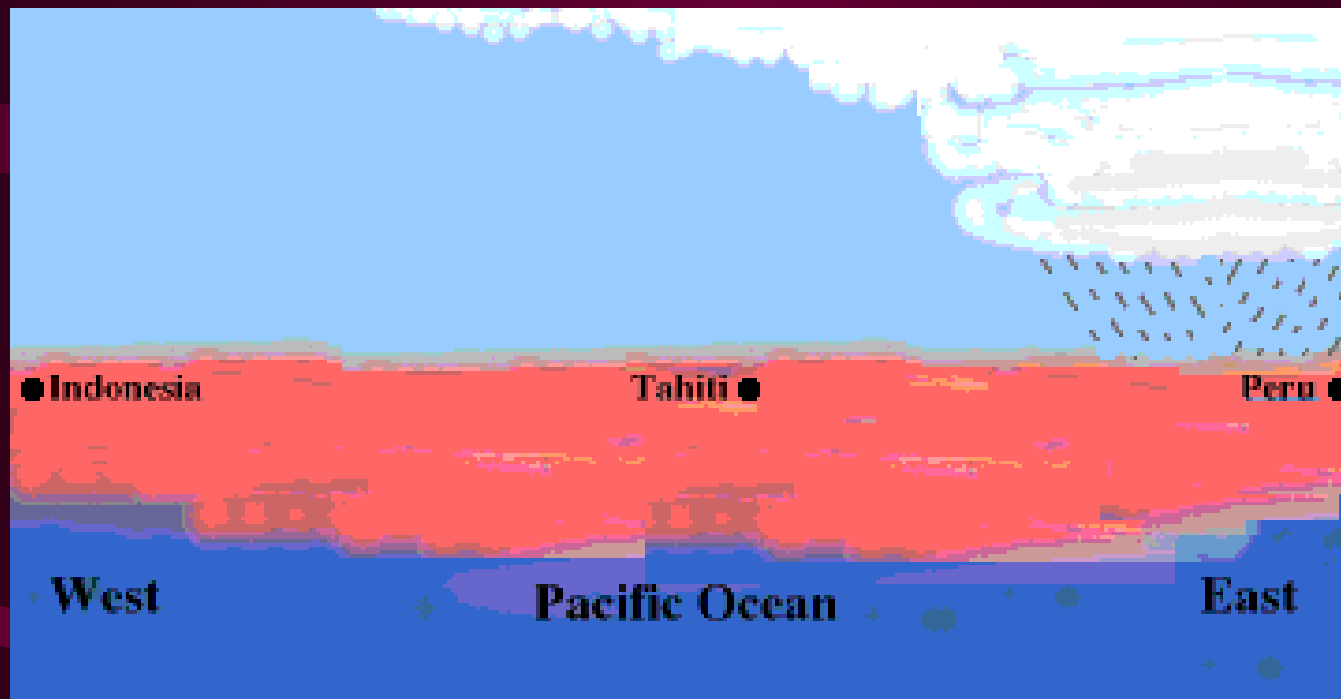


This leads to a build up of warm surface water and a sinking of the thermocline in the eastern Pacific. The deeper thermocline limits the amount of nutrient-rich deep water tapped by upwelling processes. These nutrients are vital for sustaining the large fish populations normally found in the region and any reduction in the supply of

Convective clouds and heavy rains are fueled by increased buoyancy of the lower atmosphere resulting from heating by the warmer waters below. As the warmer water shifts eastward, so do the clouds and thunderstorms associated with it, resulting in dry conditions in Indonesia and Australia while more flood-like con



El Niño causes all sorts of **unusual weather**, sometimes bringing rain to coastal deserts of South America which never see rain during **non-El Niño** years. The flooding results in swarming mosquitoes and

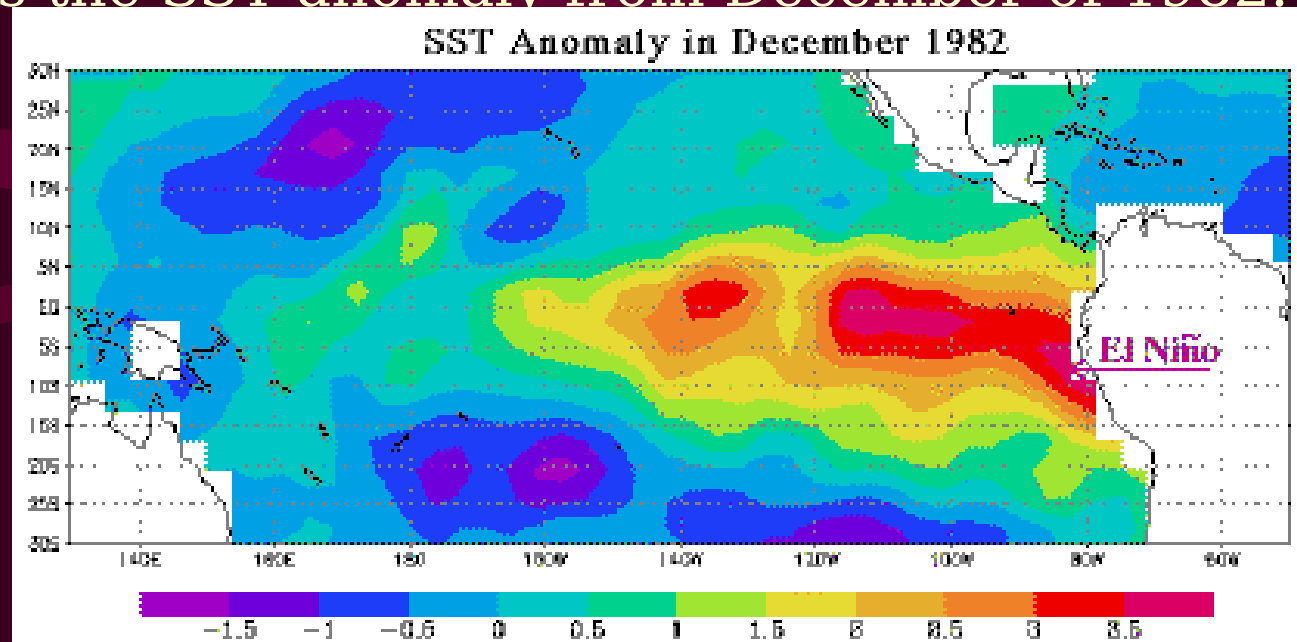


The air-sea interaction that occurs during an El Niño event feeds off of each other. As the pressure falls in the east and rises in the west, the surface pressure gradient is reduced and the trade winds weaken. This allows more warm surface water to flow eastward, which brings with it more rain, which leads to a further decrease of pressure in the east because the latent heat of

El Niño Sea Surface Temperatures

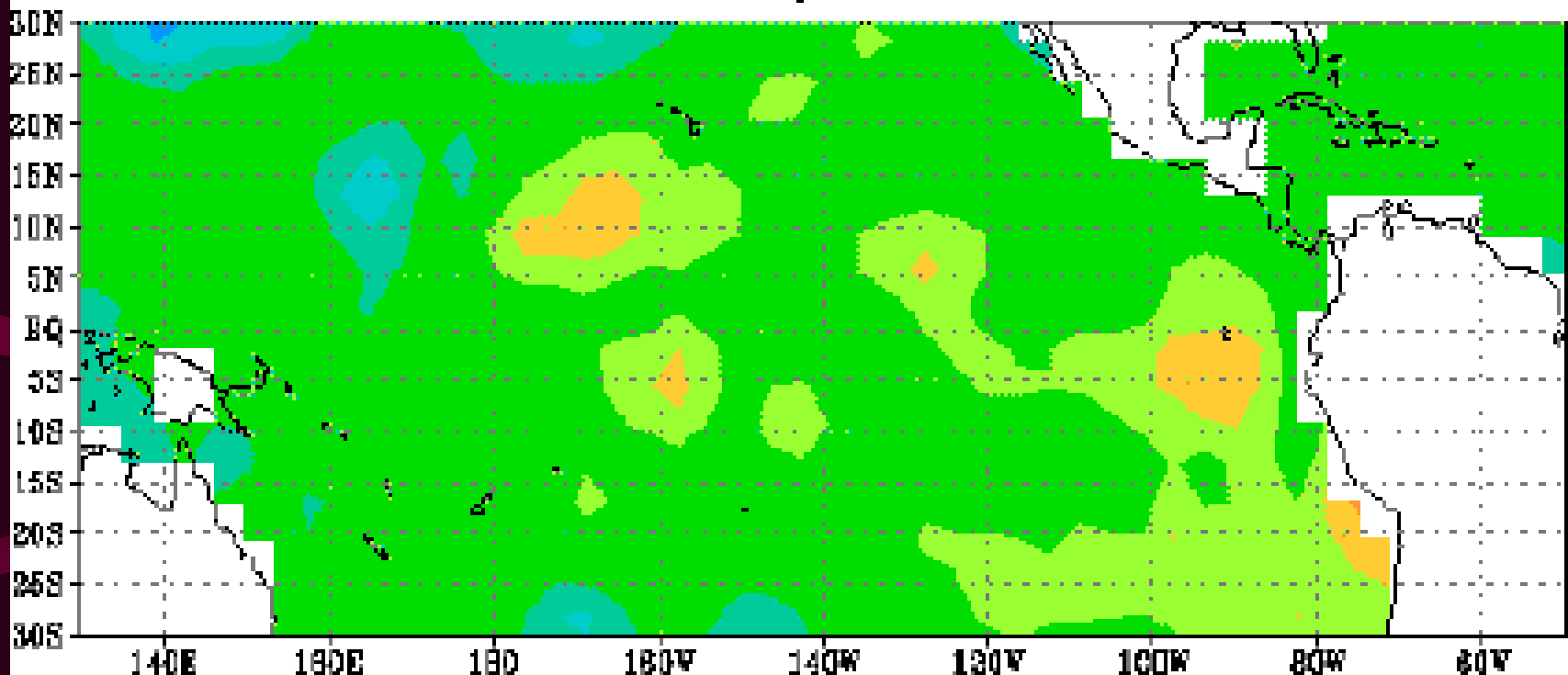
a look at the El Niño event from
1982-83

An **El Niño** event is identified by warmer than normal sea surface temperatures (SSTs). An SST anomaly plot, like the one given below, shows the difference between the observed SSTs and the normal SSTs for a given month. This particular plot depicts the SST anomaly from December of 1982.



The yellow and red shadings of the eastern Pacific indicate that the waters were considerably warmer than normal. In fact, the **El Niño** event of 1982-83 was the strongest this century, with an SST anomaly exceeding 2.5 degrees Celsius.

SST Anomaly in Jul 1982



This animation depicts the SST anomaly field from the El Niño event of 1982-83 (August 1982 to June 1983). The yellows and reds in the eastern Pacific indicate the

Atmospheric Consequences
of El Niño
influencing weather patterns
worldwide

During an El Niño year, tropical rains usually centered over Indonesia shift eastward, influencing atmospheric wind patterns world wide. Possible impacts include: a shifting of the jet stream, storm tracks and monsoons, producing unseasonable weather over many regions of the globe. During the El Niño event of 1982-1983, some of the abnormal weather patterns observed included:



Drought in Southern Africa, Southern India, Sri Lanka, Philippines, Indonesia, Australia, Southern Peru, Western Bolivia, Mexico, Central America

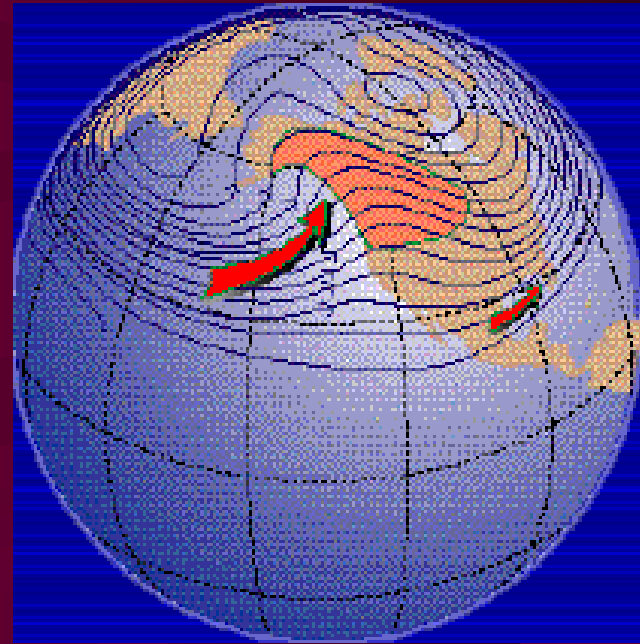
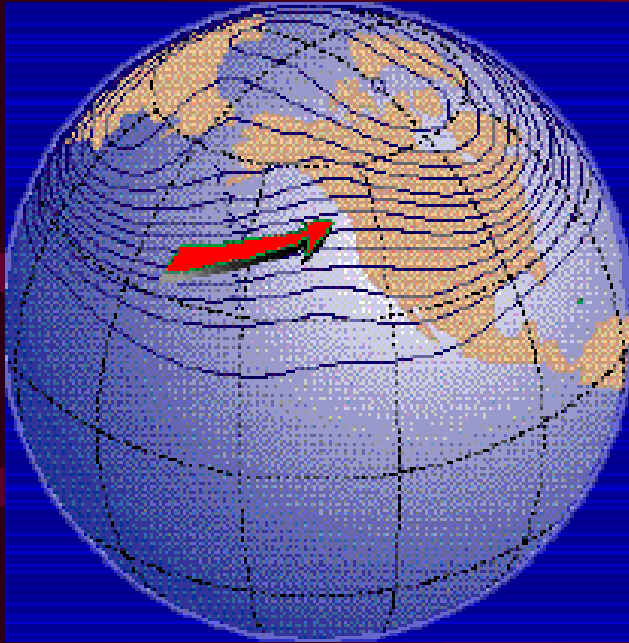


Heavy rain and flooding in Bolivia, Ecuador, Northern Peru, Cuba, U.S. Gulf States

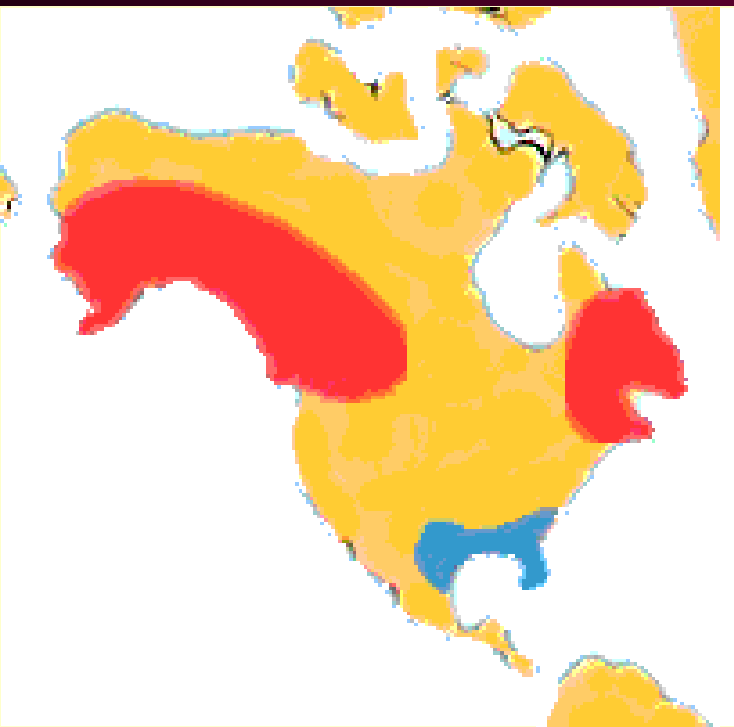


Hurricanes in Tahiti, Hawaii

The 1982-83 El Niño strengthened the upper-level ridge that was present off the West coast of the United States. (This intensification is represented by the increased amplitude of the wave in the right panel below).



The amplification led to a warming in the near-Pacific regions of North America, extending from Alaska to the northern Plains of the United States (orange shading).

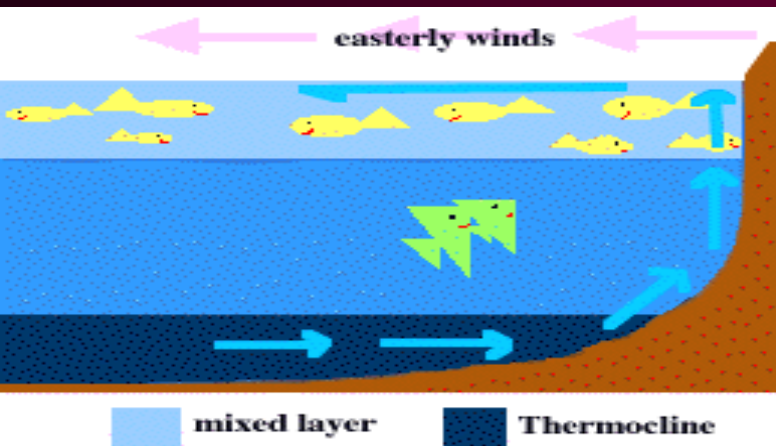


Simultaneously, the deepening of the winter **upper-level trough** (typically found over the eastern US) produced heavier than normal rains in the southern states (blue shading).

As a result of the **1982-83 El Niño** event, wide spread flooding occurred across the southern United States.

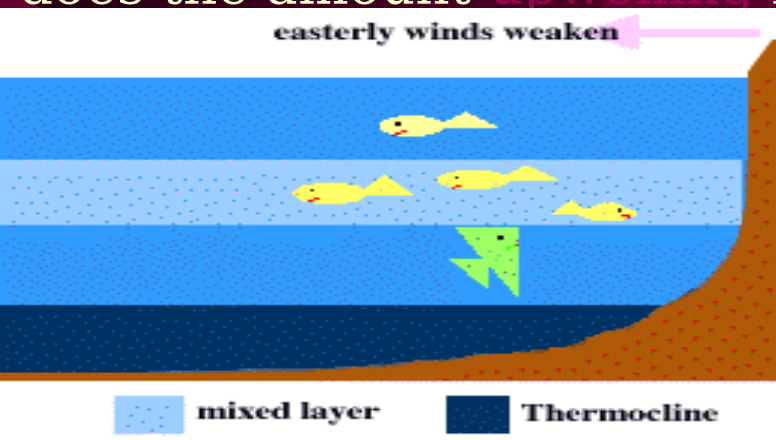
Economic Consequences of El Niño and the influence on prices worldwide

The coast of Peru is one of five major fishing grounds in the world (along with the coastal waters of California, Namibia, Mauritania, and Somalia). The abundance of fish is supported by the **upwelling** of nutrient rich waters from deeper levels (below the **thermocline**).



During non-El Niño years, the southeast **trade winds**, drag surface water westward away from shore. As surface water moves away, **upwelling** brings up colder waters from depths of 40-80 meters or more. This deep sea water is rich in nutrients which can sustain large fish populations.

During an **El Niño** event, the southeast **trade winds** weaken and so does the amount **upwelling** in the eastern Pacific.



The deeper **thermocline** means that any upwelling that does occur is unable to tap into the rich nutrients found in deeper waters. Consequently, warm nutrient-poor water predominates the eastern Pacific.

A reduction of the fish population reduces the amount of fishmeal produced and exported (by local industry) to other countries for feeding poultry and livestock. If the world's fishmeal supply decreases, more expensive alternative feed sources must be used, resulting in an increase in poultry prices worldwide.

Detection and Prediction of El Niño

current detection and numerical prediction systems

There are several means used for El Niño detection; satellites, moored ATLAS and PROTEUS buoys, drifting buoys, sea level analysis, and XBT's. Since El Niño influences global weather patterns and affects human lives and ecosystems, prediction of an El Niño event is becoming increasingly important. For short term prediction (up to 1 year) of climate variations, current observations in the Tropical Pacific are vital. Numerical models are used in many places for El Niño prediction and research. Here are some of the latest El Niño forecasts.

Given that numerical models predicting El Niño must do so months in advance, they are not as reliable as those used in predicting the weather, which forecast only days in advance. They have, however, progressed to the point where they can reproduce the characteristics of a typical El Niño event and some industries use these forecasts as

Forecasts are presented in terms of possible conditions for South America:

- (1) near normal conditions,
- (2) a weak El Niño with a slightly wetter than normal growing season,
- (3) a full blown El Niño with flooding,
- (4) cooler than normal waters offshore, with higher than normal chance of drought in South America.

Once the forecast is issued, management of agriculture, water supplies, fisheries, and other resources can be modified.